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ABSTRACT

As school organizations become more complex, the task of designing schools becomes more difficult. Not the least of the problems is determining the teaching spaces required. This report describes a new method of determining teaching accommodation needs from a statement of the school curriculum. Central to the method is a computer-based system of evaluating a school's curriculum in terms of the accommodation it requires. The system requires three main types of information. The first consists of lists of data describing work stations, group sizes, and subjects. The second is a statement of the curriculum and the third a statement of the administrative and social organization of the school. Some examples of the system are given. (Author/MLP)

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SANS

A System for Determining the Accommodation Needs of Schools

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SANS:
A SYSTEM FOR DETERMINING THE ACCOMMODATION NEEDS OF SCHOOLS

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SUMMARY

As school organizations become more complex, the task of designing schools becomes more difficult. Not the least of the problems is determining the teaching accommodation required. This report describes a new method of determining accommodation needs from a statement of the school curriculum. This work has been carried out by the Local Government Operational Research Unit on behalf of the Department of Education and Science.

Central to the method is a computer-based system of evaluating a school's curriculum in terms of the accommodation it requires. This system embraces a number of novel features and, in particular, it takes into account timetabling factors which are neglected in alternative approaches to this problem.

Our aim has not been simply to produce a sophisticated calculating machine for use by architects. From the outset the system has been oriented towards the educationist, and we believe that the final product will be a valuable aid in translating his educational philosophy into a feasible design brief.

ACKNOWLEDGEMENTS

We should like to thank all the people both inside and outside the Unit, who have contributed towards this work. Special thanks are due to the officers of the Education Departments of Derby, Durham and the Isle of Wight whose efforts and patience in preparing information and discussing the early results is greatly appreciated.

We owe much to the substantial contributions of Mr. Guy Hawkins of the D.E.S. Architects and Building Branch. Without his help, encouragement and advice this work would be the poorer; were it not for the fact that responsibility for these views and any errors in the text is our own, we would have included him as co-author.

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1. INTRODUCTION

The design of a school imposes a lasting influence on the curricula and teaching methods than can be used within it. It is therefore vitally important that the design itself reflects the educational philosophy and aims of the intended users or, at least, of those undertaking the planning on their behalf.

Once the projected numbers and ages of pupils in a planned school have been determined, the maximum area which can be provided is effectively governed by financial controls. On the other hand, minimum areas for teaching are specified in statutory regulations. Within these limits, however, education authorities have considerable freedom to determine the character and sizes of spaces according to their own wishes.

For the 40 per cent or so of the total area that will need to be devoted to non-teaching uses, such as administrative offices, kitchens, lavatories, and boiler houses, the building up of a set of requirements is relatively straightforward. No great issues of educational philosophy are involved and guidance is available from regulations and codes of practice. It is the remaining proportion, which will be used for teaching purposes, that presents the challenge – and the problems. Establishing the detailed allocation of this area involves an interpretation of the fundamental aims and methods of education – what is to be taught, to whom, and in what way, and how should the school be organized.

Until recently, only simplified methods existed for calculating these requirements. However the school organizations with which they were asked to deal were themselves relatively simple, and it was not felt that the necessary assumptions were too restrictive. Today, however, schools have become increasingly complex in their aims, methods and organizations. With wider curricula, greater range of choice and increased diversity of teaching methods, schools' space requirements have become more complicated and the methods used to determine accommodation provision need therefore to become correspondingly more sophisticated themselves.

The Local Government Operational Research Unit was commissioned by the Department of Education and Science to devise such a method. In particular it was proposed that the new method should:

- be capable of assessing several different curricula instead of one as at present. This would enable educationists to gauge the effect of innovations and to judge the 'flexibility' of various proposals.

- not be based on any particular assumptions about the size of teaching groups or organizational units, but be capable of handling any pattern of group sizes suggested – for example class teaching, team teaching and project work – within overall staffing constraints.

- enable a useful and rational allocation of spaces additional to minimal requirements to allow the greatest possible degree of organizational flexibility.

This report introduces the new method developed by the Unit, and describes both the information used as input to the system, and the results that can be expected from it.

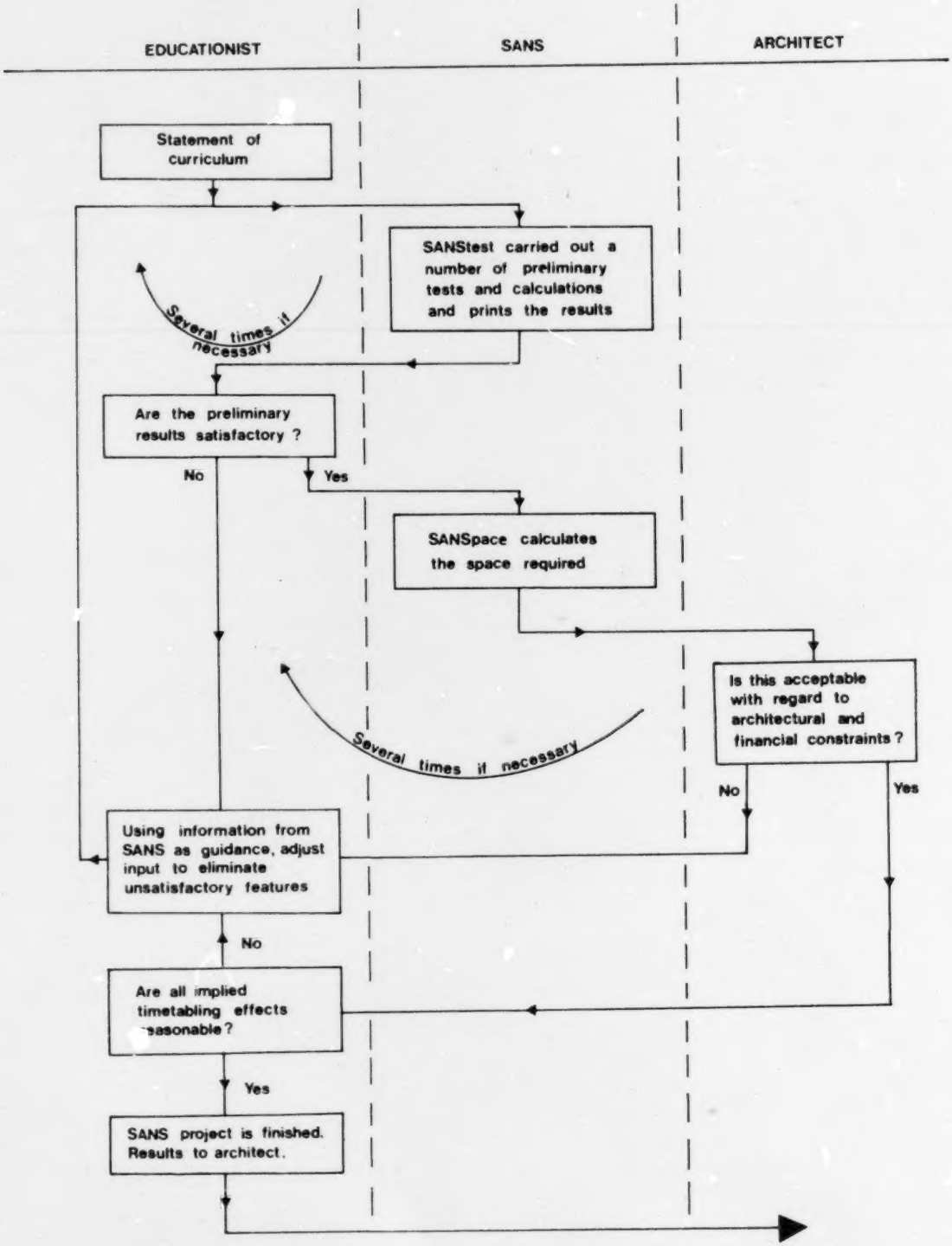
EDUCATIONIST
SANS
ARCHITECT
Statement of curriculum
SANStest carried out a number of preliminary tests and calculations and prints the results
Several times if necessary
Are the preliminary results satisfactory ?
No
Yes
SANSpace calculates the space required
Is this acceptable with regard to architectural and financial constraints ?
Several times if necessary
No
Yes
Using information from SANS as guidance, adjust input to eliminate unsatisfactory features
No
Are all implied timetabling effects reasonable ?
Yes
SANS project is finished. Results to architect.

Figure 1: The place of SANS in the design process

2. OUTLINE OF THE SYSTEM

2.1 Place of SANS in the design process

Translating an educational philosophy into a feasible design brief is a task requiring considerable skill, judgement and experience, and it is important that proposed new aids to this task should not fall into the trap of oversimplifying the problem. Nevertheless, the design process involves many calculations which can be both tedious and time-consuming, and this inevitably limits the number of design options that can be explored.

The SANS method is based on the view that the educationist and architect should devote their energies to making educational and architectural judgements respectively, and should be involved in as little drudgery as possible. Thus the part played by the method in the design process is that of calculation. It does not produce a blue-print for the school's layout, nor does it of its own accord modify input information to produce a 'better' or 'best' result. But it does provide a valuable aid by which the accommodation implications of alternative educational and organizational decisions can be evaluated. By providing a systematic and rapid assessment of different courses of action, the new method offers the designer freedom to explore a wide range of different possibilities and to experiment liberally with novel ideas. Figure 1 shows how the new method, which is in the form of a suite of computer programs, fits into the design process, at the boundary between educational and architectural decisions.

2.2 Features of the SANS System

The SANS system differs in three basic respects from the existing room-loading technique:

The System is Activity Oriented

By this we mean that the system operates in terms of the types of activity involved (e.g. note-taking, light practical work, laboratory experimentation) rather than with the attached subject name. This does not mean that 'subjects' play no part in the system, but only that the system is not oriented that way. The units of accommodation that the system uses are 'work stations' of various types. A work station is defined as being the accommodation required for a single pupil engaged in a particular activity. Thus a traditional classroom might be represented as a space containing 30 work stations of the type corresponding to desk and chair provision.

This activity oriented work station approach is based on two premises. First, that types of activity, and hence the types of accommodation demanded, generally cut across the boundaries of different subject areas. For example, upper school discussion groups may well require the same type of accommodation whether the subject matter under consideration is the structure of society or the structure of atoms. And second, that the school will be organized to take advantage of this characteristic by segregating at least part of the curriculum activities, such as note-taking, laboratory work, etc., into discrete periods. An example of such an arrangement would be the traditional split of, say, five science periods into two 'practical' lessons in the laboratory with the remaining 'theoretical' lessons taking place in classrooms. Although current thinking might favour more fluid arrangements, a situation where 40 per cent of a block-timetabled group required laboratory facilities at any one time would necessitate the same accommodation.

The advantage in working in terms of activities in this way is that, other things being equal, a more flexible – and thus less wasteful – usage of space is possible. We recognize, of course, that any gains to be realized from this approach will need to be assessed against the advantages offered by the alternative subject-oriented approach. But the latter approach will itself have disadvantages, although these may not always be explicit. For instance, the efficient use of rigidly departmentalized schools can often only be achieved at the expense of severely constraining the variety of group sizes, teaching methods and types of accommodation. These disadvantages manifest themselves not in terms of utilization factors, but in terms of the quality of the educational experiences that the children receive. It is a common theme throughout this report that the methods we have used have been adopted not in an attempt to impose them on others, but to allow potentially advantageous developments to be compared with known and proven arrangements.

The System Explicitly Considers Variation in Teaching Group Sizes

With the room-loading technique, the basic calculations are performed on the assumption that all teaching groups will be standard units of, say, 30 children. Some recognition of the unreality of this assumption is made by subsequently increasing the areas so calculated by a 'flexibility factor' which might, typically, be 15 per cent for a particular type of space. The SANS system, on the other hand, deals with the actual teaching group sizes envisaged by the educationist. However, the freedom that the system gives to manipulate more realistic information does not compel the educationist to supply an artificial level of detail where he feels that this would not be justified. Although the system has been designed to accept detailed data, it is equally able to work with crude data for parts of the curriculum.

A consequence of allowing the educationist to specify a wide variety of group sizes is that the requirements for different parts of the curriculum and for different year groups may not be very compatible with each other. For example some rooms or spaces, while being well used in terms of the number of periods in the week that they are occupied, may be poorly used in terms of the number of pupils present on most occasions. The whole basis of the SANS system is that by an iterative process of modification and re-running, such features can be reduced to an acceptable level. Although this process represents some movement away from the educational ideals represented by the initial input information, it should nevertheless generate spaces that will still be determined primarily by that information.

The System Considers Timetabling Factors

Every practical school design imposes timetabling constraints. An obvious, if trivial, example concerns the provision of specialist accommodation such as laboratories. The number of laboratory spaces provided in any school is only a fraction of the total number of children in the school, and this represents an upper limit to the proportion of children who can be simultaneously timetabled to laboratory activities. However, other less obvious restrictions may be implicit in a design, and it is important that these are recognized. For example an arrangement which appears on paper to be well-utilized may achieve this state only if groups are timetabled evenly throughout the week, and this could prevent the use of team teaching techniques.

SANS deals with this problem in two ways. First, requirements for simultaneous timetabling of particular groups, such as when block timetabling is anticipated, or is at any rate being planned for, are entered with the curriculum information. Requirements for non-simultaneous timetabling on grounds other than the optimum usage of space, such as when a single specialist teacher will need to take all classes of a particular subject, are entered at the same time. These requirements are always satisfied by the system, though the programs

will output information that indicates the circumstances where relaxing these 'time constraints' would be beneficial. Second, the system can be asked to print out the assignments of classes to each room in each period that it has used in producing the final result. These tables can be examined to confirm that no untenable assumptions have been made. These aspects of the system are considered more fully in Chapter 5.

The system works with curricula expressed in terms of numbers of periods per week (or, more precisely, per curriculum cycle) rather than as percentages. In reality, the proportions of the week allotted to different subjects can only be timetabled in discrete steps, and this has consequences for space provision. While the use of a notional number of periods per week is an assumption made for planning purposes and represents no commitment for the eventual staff, it does afford the opportunity of testing the apparent ease of operating the school with various numbers of periods.

In addition to the three factors above, which are basic differences from the room-loading technique, a fourth feature of the SANS system arises from its capacity to manipulate large quantities of data with great speed.

The System Considers Organizational Arrangements

New schools are seldom built or operated in an entirely integrated way in which all year groups make use of all spaces in a completely flexible manner. Many schools are divided, organizationally if not physically, into upper/lower or upper/middle/lower blocks, or into general and specialist teaching blocks. Further subdivisions may be made to provide home bases so that groups of children can identify with a unit smaller than the entire school. In addition to posing problems of spatial layout such arrangements generally lead to some duplication of teaching facilities. For any specified arrangement of this type, SANS can calculate the nature and magnitude of this effect so that it can be weighed against the potential advantages.

3. INFORMATION REQUIRED BY THE SYSTEM

The system requires three main types of information. The first consists of lists of data describing work stations, group sizes and subjects. The second is a statement of the curriculum and the third a statement of the administrative and social organization of the school. We consider each in turn.

3.1 Preliminary Data Lists

As Figure 1 shows, the basis of the calculations made by the new system is a statement of the school's curriculum. In order to enter this data to SANSTEST, the first of the SANS suite of programs, some initial lists of basic information must be drawn up. Although the work required to do this for a real project is very small, the data required is described here at some length in order to develop a 'feel' for the way in which the system works.

List 1: Work Station Types

This is a list of the different types of teaching accommodation which are likely to be needed in the school. The work station types are specified by the user of the system entirely according to his own wishes – there is in no sense a predetermined set of types from which he must select. At all stages this list is provisional and it can be expanded or reduced whenever the need is apparent. An example of such a list is shown in Figure 2, and the more important features are elucidated below.

Type	Name	
1	WRITING	Closed
2	WRITING	Open
3	DISCUSSION	Closed
4	DISCUSSION	Open
5	LIGHT PRACTICAL	Closed
6	LIGHT PRACTICAL	Open
7	HEAVY PRACTICAL	Open
8	LABORATORY	Closed
9	LABORATORY	Open
10	ART/CRAFT	Closed
11	ART/CRAFT	Open
12	HOME ECONOMIC PRAC.	Open
13	SPORTS HALL	Open
14	DRAMA STUDIO	Closed
15	LIBRARY	Open
16	COMPUTING ROOM	Closed
17	LANGUAGE LAB.	Closed

Figure 2: Specimen list of work station types

1. Work station types are distinguished according to activity (e.g. writing, laboratory, craft, etc.) rather than by size (as in tutorial room, seminar room, class room). The latter names could be attached subsequently to rooms of the appropriate sizes. Work station types equivalent to a 'subject' name can be used where the type is so specialized as to be unusable for anything else, e.g. some aspects of Home Economics – type 12 above.

2. Several of the types appear as pairs, one 'open' and the other 'closed'. This allows a distinction to be made between activities requiring 'rooms', and those which can take place in open plan areas. Open plan areas may be used either because of a definite requirement (as in a team teaching situation) or because a traditional room is not necessary, in which case the greater flexibility of an open plan area may be preferred.

3. In a similar way, the general teaching accommodation is split into more than one category, so that the less sophisticated can be selected whenever it is adequate, or even preferable, on educational grounds.

4. The list shows some types of accommodation, such as 15: Library and 16: Computing Room, which are of a rather different character from the majority. The sizes of these types of accommodation would not be determined by the number of classes timetabled to use them, but by other criteria. For the purposes of a SANS study, however, they can be listed to facilitate the checks on missing data (see Chapter 4).

List 2: Identification and Sizes of Primary Groups

The method can, if required, consider the curricula of individual pupils but in practice the educationist is likely to find it more convenient to divide the school into what we have called 'primary groups' or, interchangeably, 'pupil groups'. These groups are defined in such a manner that all pupils belong to one and only one group and that all pupils in the same group have identical curricula. This does not imply that each child within a given group studies the same subjects as all others in the group, but that he or she has the same range of options as everyone else in the group.

The most obvious type of pupil group is the year group but this is by no means the only structure. One might for example treat the first three years as a single group, the fourth and fifth years as a second group, and the sixth form as several smaller groups (see Figure 3).

REF. NO.	DESCRIPTION	NO. OF PUPILS
1	YEARS 1+2+3	540
2	YEARS 4+5	360
3	YEARS 6+7 (part)	50
4	YEARS 6+7 (remainder)	100

Figure 3: Example of primary group classification

Lists 3 and 4: Subjects in the Curriculum

'Subject' need not be interpreted in the well defined traditional sense, but can be in whatever form the educationist finds most useful to describe curricula. Although the names attached to particular teaching activities do not have any direct effect on the accommodation required, it is convenient to make use of them for a number of reasons. First, it makes entering of curriculum information to the system easier if names can be used rather than working entirely with numeric codes. Second, it makes the interpretation of the output information much simpler for the same reason. Third, it allows detailed staffing ratio calculations to be presented in familiar terms. For the latter purpose, a breakdown by individual subject is generally too detailed, and the ratios are in fact calculated for desired groupings of subjects, e.g. departmentally. This grouping information is contained within the codes which are assigned to the list, as can be seen from the example shown in Figure 4.

SUBJECT GROUP	SUBJECT
1. HUMANITIES	101 Integrated Study
	102 English
	103 Drama
	104 Languages
	105 Social Sciences
	106 R.E.
2. SCIENCES	201 Science
	202 Mathematics
3. ARTS/CRAFTS	301 Art
	302 Boys Craft
	303 Girls Craft
4. P.E./Games	401 Boys P.E.
	402 Girls P.E.
	403 Games
5. OTHER	501 Music
	502 Careers
	503 Commerce
	504 Outside Activity

Figure 4: Specimen lists of subjects and subject groupings.

3.2 A Statement of the Curriculum

Equipped with these basic lists, the educationist can now enter the curriculum data to the system. This is done by working systematically through each primary group/subject combination in the curriculum and constructing 'lines' of data. These lines are statements of the way in which particular pupils within primary groups will split into subgroups of different sizes, the work station types they will require, and the timetabling pattern envisaged. By coding the lines in different ways, the system can accept and manipulate a whole spectrum of intention, and it is therefore incumbent on the educationist to express

his wishes explicitly. Figure 5 gives some examples of the range of choice which can be accommodated. As we have stated earlier, being able to do so does not compel the educationist to supply an artificial level of detail, provided only that he is unambiguous in his intentions. With no instructions to the contrary, the system will assume that timetabling will be carried out in the way that minimizes the total accommodation required.

3.3 Statement of the Administrative/Social Organization

As we have already noted in section 2.2, no purpose-built contemporary school would be designed solely on the basis of the teaching organizations as specified above. Two other major operational factors superimpose a further pattern of organization. These are administrative considerations, leading, for example, to organizationally discrete science or art blocks, and social considerations, leading to upper/lower school blocks and sometimes

Basic curriculum requirement

Year 1 English for a 6 form entry school will be assigned 5 periods of a notional 35-period week.

Alternative detailed organizations

1. All 180 pupils will be timetabled simultaneously for each period. Three of the periods will be in 'open'-type accommodation, with the other two in closed rooms in subgroups of 30 pupils each.

2. All 180 pupils will be timetabled simultaneously for each period, 60 per cent to be in 'open'-type areas and 40 per cent in closed rooms.

3. The primary group will split into subgroups, such as two of 90 pupils each, or six of 30 pupils each. Each subgroup will be timetabled simultaneously with the same mix of accommodation types as (2), but there is to be no occasion in the week when more than one subgroup is timetabled at the same time.

4. The primary group is to be split into, say, six subgroups of 30 for four of the periods, but two of 90 for the fifth period. In other words, the requirement is that three of the subgroups of 30 would occasionally come together so that they might attend a lecture.

Figure 5: Example of alternative organizations of a basic curriculum requirement.

to home-base areas within such blocks. Since these factors will usually have consequences for the total amount of teaching space that is necessary in the school, they must be taken into account by the system. The very simple way in which this information can be specified for coding is illustrated in Figure 6: a list of 'blocks' is drawn up and every subject/primary group combination is assigned to one of these blocks.

BLOCK NAME AND NUMBER	SUBJECTS AND PRIMARY GROUPS INCLUDED
1. FIRST YEAR HOME BASE	All subjects for PG1, except those specified in Blocks 4 and 6.
2. SECOND YEAR HOME BASE	All subjects for PG2, except those specified in Blocks 4 and 6.
3. THIRD YEAR HOME BASE	All subjects for PG3, except those specified in Blocks 4 and 6.
4. LOWER SCHOOL SPECIALIST	Science and arts/crafts practical facilities for PG's 1 – 3.
5. UPPER SCHOOL	All subjects except music for all PG's except 1 – 3.
6. MUSIC	Music only for every PG.

Figure 6: Example of 'blocking' specification

With data collected and specified in this way, the first run of the programs can be carried out. In the next chapter we describe the output of the system in terms of data checks and space requirements.

CURRICULUM DATA •••• •••• PAGE 4

PUPIL GROUP	NUMBER OF REPEATS	SUBJECT CODE	DESCRIPTION	TOTAL PER	NUMBER OF PUP	TCH	WORK STN.	TYPE	NUMBER OF PLACES	ROOM DETAILS	CARD SEQ.
PG 3	3	0301	LANGUAGES	1	60	2	WS	2	40	20 20	230
							WS	5	20	20	
PG 3	3	0301	LANGUAGES	1	60	2	WS	2	20	20	240
							WS	5	40	20 20	
PG 3	3	0301	LANGUAGES	2	60	2	WS	2	60	20 20 20	250
PG 3	2	0601	SOCIAL STUDIES	4	90	4	WS	2	90	30 25 25 10	260
PG 3	6	0601	R.E.	1	30	1	WS	2	30	30	270
PG 3	3	0801	ART	3	60	4	WS	10	10	10	280
							WS	12	25	25	
							WS	9	25	25	
PG 3	3	0701	SCIENCE	4	60	3	WS	11	60	20 20 20	290
PG 3	3	0901	GIRLS' CRAFT	1	30	2	WS	12	15	15	300
							WS	14	15	15	
PG 3	3	0901	GIRLS' CRAFT	1	30	2	WS	12	30	30	310
PG 3	3	0901	GIRLS' CRAFT	1	30	2	WS	14	30	30	320
PG 3	3	1001	BOYS' CRAFT	3	30	1	WS	17	30	30	330
PG 3	9	1101	DRAMA	1	20	1	WS	7	20	20	340
PG 3	3	1201	MUSIC	2	60	2	WS	3	60	30 30	350
PG 3	6	1301	PHYSICAL ED.	2	30	2	WS	18	15	15	360
							WS	19	15	15	
PG 3		1401	GAMES	2	180	6	WS	18	40	40	370
							WS	21	120	120	
							WS	19	20	20	
PG 4	2	0201	ENGLISH	5	90	6	WS	2	66	22 22 22	380
							WS	5	4	4	
							WS	7	10	10	
							WS	16	10	10	

Figure 7: Specimen listing of curriculum information

4. OUTPUT FROM THE SYSTEM

The system consists of two main computer programs. The first, SANSTEST, checks that the data is correctly specified and sorts it into a form in which the second program, SANSPACE, can use it to calculate minimum space requirements.

4.1 Preliminary results from SANSTEST

When the data has been coded, it is read into SANSTEST, the first of the SANS programs. This program carries out a number of tests to ensure that the data, which has been compiled in a piecemeal fashion, is self-consistent and feasible. It prints out the results of these checks along with a copy of the input information (see Figure 7). The checks are of two types, those that are carried out on a line-by-line basis as the data is fed in, and those that relate to the curriculum information as a whole.

Line-by-line checks

In addition to tests designed to identify coding and punching errors, two educational tests are carried out:

1. A warning is printed on each line where the number of places requested exceeds the number of pupils in the subgroup in question. Such a difference, referred to as line over-specification could arise:

   a) from a mistake, which would be corrected,

   b) as a deliberate intention, in which case it will be important to remember that for this part of the curriculum, slack has been introduced from the outset,

   c) as a consequence of rounding, (for example a request for 25 pupils to be split into two equal sized teaching groups would be interpreted as a request for two rooms, each of at least 13 places).

2. A warning of potential supervision problems is printed whenever the number of teachers assigned to a line is less than the number of separate groups requested. Again, this discrepancy may be intentional, as in some sixth form situations, or it may be inadvertent.

Aggregate Checks and Calculations

These are of three different types:

1. A comparison is made between the total number of pupil-periods for which teaching organization data has been supplied, and the product of the total number of pupils in the appropriate pupil group with the number of periods in the week. Any differences are printed out, along with the cumulated line specifications determined above (see Figure 8). Negative values for the difference (termed period **under**-specification) indicate that some data has been omitted. Positive values (period **over**-specification) point to duplication of input, which could be unintended, or could arise legitimately in situations where pupils are to be offered a free choice of options.

THIS TABLE RELATES THE TOTAL NUMBER OF PERIODS*PLACES REQUESTED TO THE TOTAL NUMBER OF PUPILS*PERIODS PER WEEK (CURRICULUM CYCLE)

LINE SPECIFICATION NOT EQUAL TO ZERO MEANS THAT, FOR SOME LINES OF DATA, THE NUMBERS OF PLACES REQUESTED DIFFERS FROM THE NUMBER OF PUPILS FOR THAT LINE

NEGATIVE VALUES OF PERIOD SPECIFICATION SUGGEST THAT DATA FOR PART OF THE CURRICULUM HAS BEEN OMITTED. POSITIVE VALUES CAN OCCUR IN OPTION SITUATIONS

PUPIL GROUP	LINE SPECIFICATION	PERIOD SPECIFICATION
1	690	0
2	690	0
3	10	0
4	42	0
5	42	0
6	19	-917
7	18	-924

Figure 8: Example of the test that curriculum data is complete

THIS INFORMATION IS PROVIDED AS A CHECK THAT THE STAFFING IMPLICATIONS OF THE CURRICULUM DATA ARE REASONABLE. READING ALONG A ROW SHOWS THE VARIATION FROM ONE SUBJECT GROUP TO ANOTHER WITHIN A PUPIL GROUP. READING DOWN A COLUMN SHOWS THE WAY IN WHICH AVERAGE GROUP SIZES VARY FROM ONE PUPIL GROUP TO ANOTHER FOR A PARTICULAR SUBJECT GROUP

PUPIL GROUP	OVERALL RATIO FOR THIS PG	PUPIL-TEACHER RATIOS BY SUBJECT GROUP FOR EACH PUPIL GROUP									
		1	2	3	4	5	6	7	8	9	10
1	19.6	18.6	0.0	0.0	22.5	0.0	0.0	20.0	15.0	15.0	30.0
2	19.6	18.6	0.0	0.0	22.5	0.0	0.0	20.0	15.0	15.0	30.0
3	19.5	0.0	15.6	24.0	22.5	22.5	30.0	20.0	15.0	15.0	30.0
4	16.7	0.0	12.9	11.7	16.2	21.2	30.0	19.2	10.7	15.0	20.0
5	16.7	0.0	12.9	11.7	16.2	21.2	30.0	19.2	10.7	15.0	20.0
6	8.9	0.0	10.4	5.5	7.8	10.8	6.0	14.4	4.9	2.8	4.0
7	6.9	0.0	7.4	5.0	6.1	8.3	0.0	13.8	4.0	2.0	1.7

OVERALL RATIO FOR ALL SCHOOL	RATIO BY SUBJECT GROUP FOR ALL SCHOOL									
	1	2	3	4	5	6	7	8	9	10
16.6	18.6	12.4	11.5	15.7	16.8	25.6	18.2	11.7	12.6	15.6

Figure 9: Specimen table of staffing ratios

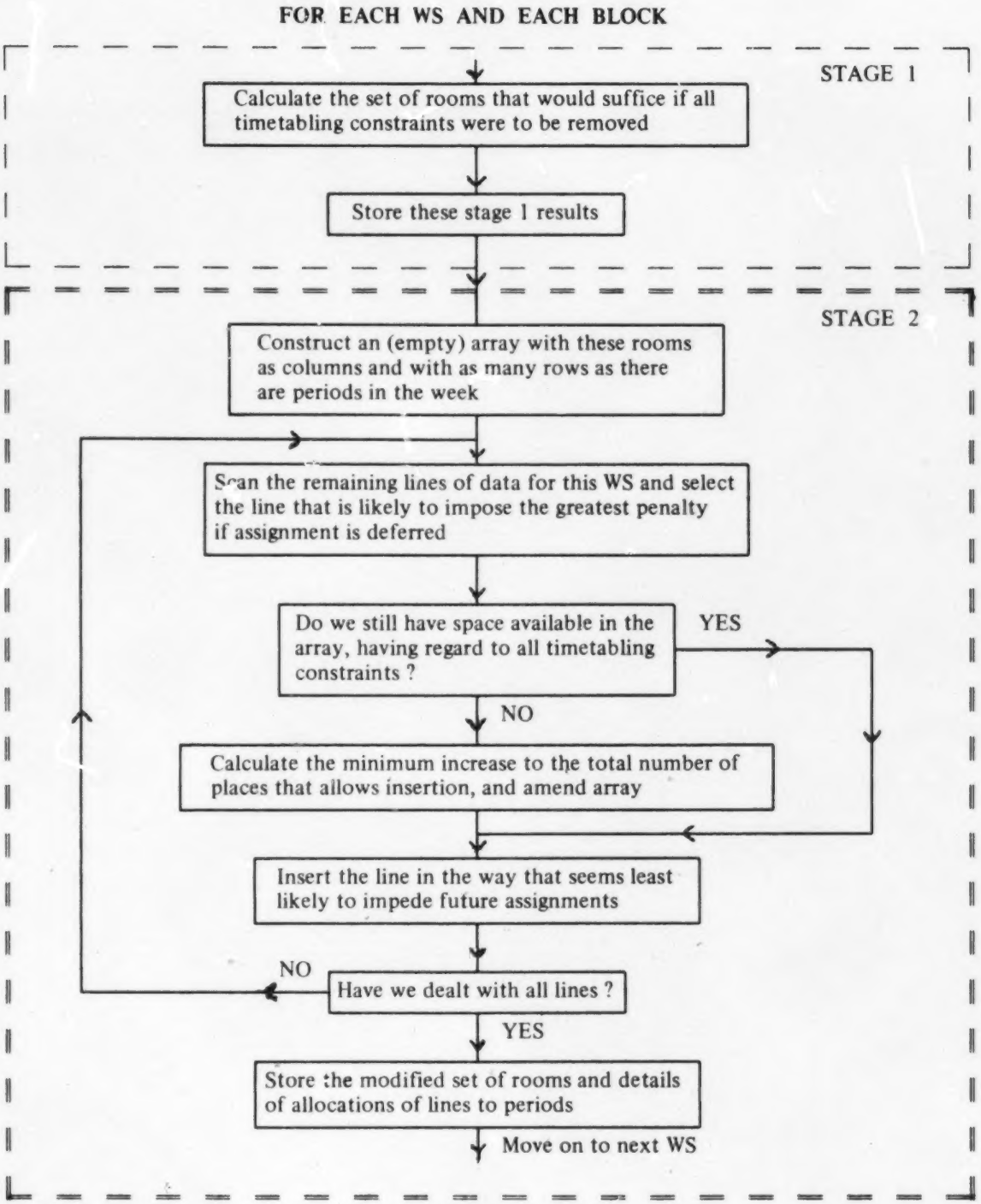
FOR EACH WS AND EACH BLOCK
STAGE 1
Calculate the set of rooms that would suffice if all timetabling constraints were to be removed
Store these stage 1 results
STAGE 2
Construct an (empty) array with these rooms as columns and with as many rows as there are periods in the week
Scan the remaining lines of data for this WS and select the line that is likely to impose the greatest penalty if assignment is deferred
Do we still have space available in the array, having regard to all timetabling constraints ?
YES
NO
Calculate the minimum increase to the total number of places that allows insertion, and amend array
Insert the line in the way that seems least likely to impede future assignments
NO
Have we dealt with all lines ?
YES
Store the modified set of rooms and details of allocations of lines to periods
Move on to next WS

Figure 10: Outline of SANSPACE algorithms

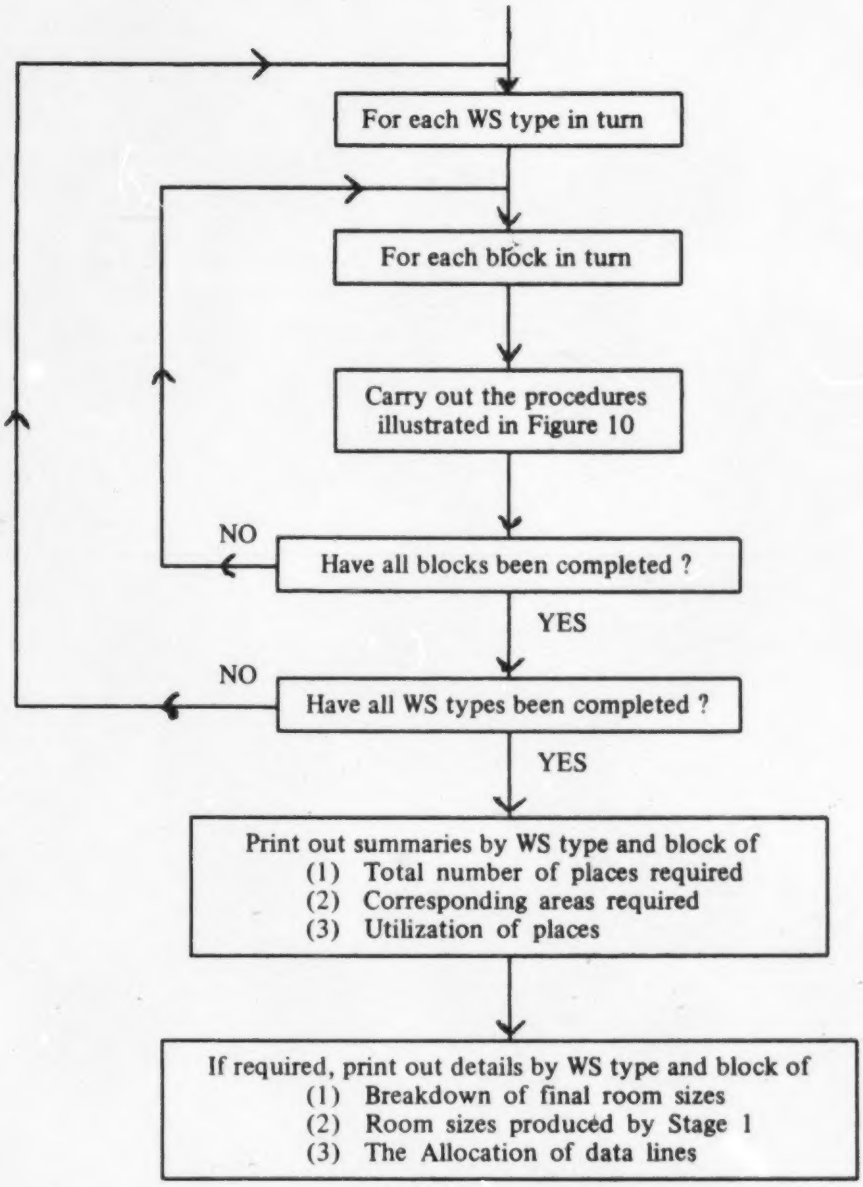
For each WS type in turn
For each block in turn
Carry out the procedures illustrated in Figure 10
NO
Have all blocks been completed ?
YES
NO
Have all WS types been completed ?
YES
Print out summaries by WS type and block of
(1) Total number of places required
(2) Corresponding areas required
(3) Utilization of places
If required, print out details by WS type and block of
(1) Breakdown of final room sizes
(2) Room sizes produced by Stage 1
(3) The Allocation of data lines

Figure 11: Output information available from SANSPACE

2. Some simple tests are carried out to detect timetable infeasibilities implicit within the data. For example it would be logically impossible to timetable a situation where, with a 35-period week, sixth formers were to be invited to combine any three A-level subjects from a list of ten, when each would require 7 periods attendance weekly. (Strictly speaking this would be possible if courses were to be repeated at different times within the week, but this solution would need to be recognized by the addition of further lines of data.)

3. Staffing ratios implied by the curriculum data are calculated by subject group and by primary group. These can be examined by the educationist to determine whether unrealistic staffing levels have been assumed and whether a 'fair' distribution of ratios between age groups or subjects has been achieved. Impractical staffing levels affect the provision of accommodation in that a school designed on the basis of, for example, low staffing ratios would have a higher proportion of small rooms than a realistically staffed school would wish to use. An example of the way in which these ratios are presented is shown in Figure 9. One point that should be borne in mind is that these ratios represent the average number of pupils with the teachers in those periods that they are actually teaching. In order to compare these ratios with any rules-of-thumb that may be currently used for assessing staff requirements, these ratios would need to be reduced by a factor to take account of the part of the week spent by staff in non-teaching activities.

4.2 Space Requirements from SANSPACE

When the data has passed successfully through SANSTEST, it is entered to SANSPACE, the core of the SANS system. The objective of this program is to calculate the minimum set of spaces that, subject to all constraints on work station type, group sizes and timetabling factors, could accommodate the specified curriculum. It does this in two stages, as illustrated schematically in Figure 10.

Stage 1 calculates the set of rooms and open spaces that would be sufficient to contain the teaching requirements if all timetabling constraints were to be ignored – in other words, if the numbers and sizes of teaching groups are taken as specified, but no account is taken of simultaneity or non-simultaneity conditions. Although these results are somewhat artificial, their comparison with the final output highlights ways in which compromises to the original requirements could lead to significant improvements in the usage of space.

It is the Stage 2 procedures however that constitute the significant difference between SANS and other systems. These are the procedures that take account of the actual timetabling requirements specified by the educationist. The method adopted is, in effect, to build up a timetable for the set of rooms determined in Stage 1. Whenever a situation is encountered where it is no longer possible to insert the next line of data without violating one of the timetabling constraints, the program identifies the change to the set of rooms that, with least penalty in terms of extra places, will allow insertion. This change could involve increasing the sizes of one or more of the rooms of this work station type in the current set, adding further rooms to the set, or a combination of these. Subsequent attempts to insert lines of data are made with respect to this modified set of rooms, and this process is continued until all lines have been accounted for (Figure 10).

These procedures are carried out for each work station type in each block in turn (Figure 11). In addition, a parallel set of calculations is carried out for each work station type as though the school were to be organized with complete disregard for the blocking

structure specified. Comparison of the numbers of places resulting from adding the numbers from the separate blocks, with the numbers for the 'integrated' school (i.e. with no blocking) highlights areas where the provisional blocking arrangements would prove extravagant in terms of space and cost. In practice the apparent superior flexibility of the integrated school would probably not be achieved due to organizational difficulties which the blocking principle recognizes.

The output from Stage 2 is provided at two levels of detail. First, a number of compact summary tables are printed on completion of every run, to allow easy recognition of the dominant features, and to provide a perspective of the outcome for the whole school. These are all provided in the same form as the two most important tables which are illustrated in Figures 12 and 13. The summaries show for each work station type:

1. The numbers of places required (Figure 12).

2. The corresponding areas (if information on unit areas to be used is supplied by the user).

3. The overall space utilizations (Figure 13).

4. The number of rooms into which the places are to be collected.

Second, much more detailed information can be printed on request (Figure 14). This includes:

1. Lists giving the number of places in each room.

2. The set of room sizes produced by Stage 1.

3. Allocations of lines of data to specific rooms and periods.

4. The utilizations of every room, in terms of both the number of periods in the week that it would be occupied, and the overall utilization taking into account that it would not be full every time it was occupied.

Examination of these outputs points to ways in which improvements can be made, as well as providing a direct means of comparing alternative teaching organisations, curricula, etc. In the final chapter of this report, we describe a few of the ways in which this information can be used in practice.

NUMBERS OF WORK STATIONS WITH AND WITHOUT BLOCKING

NO.	WORK STN. TYPE		SUM WITHOUT BLOCKING	SUM WITH BLOCKING	SUM FOR EACH BLOCK 1	2	3	4	5	6
1	DESK AND CHAIR	O	55	103	40	40	0	23	0	0
2	DESK,CHAIR AVA	C	335	463	67	67	128	201	0	0
3	MUSIC SEMINAR	C	60	60	0	0	0	0	0	60
4	LISTENING ONLY	O	15	15	0	0	0	15	0	0
5	LISTENING ONLY	C	60	85	0	0	40	45	0	0
6	COMPUTER TRMNL	C	10	10	0	0	0	10	0	0
7	DRAMA STUDIO	C	52	52	0	0	0	32	20	0
8	LIGHT,DRY PRAC	O	0	0	0	0	0	0	0	0
9	LIGHT,DRY PRAC	C	181	224	50	50	37	87	0	0
10	PHOTOGRAPHY	C	10	10	0	0	0	10	0	0
11	SCIENCE LAB	C	161	180	0	0	0	120	60	0
12	ART AND CRAFT	O	60	60	0	0	0	30	30	0
13	POTTERY	O	0	0	0	0	0	0	0	0
14	HOME ECON PRAC	O	45	60	0	0	0	30	30	0
15	COMMERCE PRAC	C	15	15	0	0	0	15	0	0
16	LIBRARY	O	20	20	0	0	0	20	0	0
17	HEAVY PRAC	O	50	70	0	0	0	40	30	0
18	ACTIVITY HALL	O	45	45	0	0	0	0	0	45
19	SPORTS HALL	O	60	60	0	0	0	0	0	60
20	MUSIC PRAC	C	2	2	0	0	0	0	0	2
21	OUTS.DF ACTIVITY		120	120	0	0	0	0	0	120
22	LECTURE HALL	C	90	90	0	0	0	90	0	0
	******		*****	*****						
	TOTALS		1446	1744	157	157	205	768	170	287
	******		*****	*****						

Figure 12: Specimen output showing numbers of work stations by work station type and by block

WORK STATION UTILISATION WITH AND WITHOUT BLOCKING

UTILISATIONS ARE DEFINED HERE AS BEING THE NUMBER OF PUPILS*PERIODS PER WEEK DIVIDED BY THE NUMBER OF PLACES*PERIODS. THEY ARE EXPRESSED AS PERCENTAGES

INFORMATION ON PERIOD UTILISATIONS IS CONTAINED IN THE ALLOCATION DETAILS

NO.	WORK STN. TYPE		UTILISATION WITHOUT BLOCKING	UTILISATION WITH BLOCKING	UTILISATION FOR EACH BLOCK					
					1	2	3	4	5	6
1	DESK AND CHAIR	C	92%	43%	48%	48%	0%	27%	0%	0%
2	DESK,CHAIR AVA	C	92%	67%	52%	52%	59%	83%	0%	0%
3	MUSIC SEMINAR	C	55%	55%	0%	0%	0%	0%	0%	55%
4	LISTENING ONLY	C	49%	49%	0%	0%	0%	49%	0%	0%
5	LISTENING ONLY	C	58%	40%	0%	0%	18%	60%	0%	0%
6	COMPUTER TERMI	C	22%	22%	0%	0%	0%	22%	0%	0%
7	DRAMA STUDIO	C	73%	73%	0%	0%	0%	58%	97%	0%
8	LIGHT,DRY PRAC	C	0%	0%	0%	0%	0%	0%	0%	0%
9	LIGHT,DRY PRAC	C	81%	64%	69%	69%	28%	76%	0%	0%
10	PHOTOGRAPHY	C	55%	55%	0%	0%	0%	55%	0%	0%
11	SCIENCE LAB	C	85%	79%	0%	0%	0%	85%	68%	0%
12	ART AND CRAFT	C	88%	88%	0%	0%	0%	80%	97%	0%
13	POTTERY	C	0%	0%	0%	0%	0%	0%	0%	0%
14	HOME ECON PRAC	C	72%	53%	0%	0%	0%	56%	51%	0%
15	COMMERCE PRAC	C	48%	48%	0%	0%	0%	48%	0%	0%
16	LIBRARY	C	40%	40%	0%	0%	0%	40%	0%	0%
17	HEAVY PRAC	C	81%	57%	0%	0%	0%	63%	51%	0%
18	ACTIVITY HALL	C	73%	73%	0%	0%	0%	0%	0%	73%
19	SPORTS HALL	C	62%	62%	0%	0%	0%	0%	0%	62%
20	MUSIC PRAC	C	11%	11%	0%	0%	0%	0%	0%	11%
21	OUTSIDE ACTIVITY		27%	27%	0%	0%	0%	0%	0%	27%
22	LECTURE HALL	C	17%	17%	0%	0%	0%	17%	0%	0%
	******		*****	*****						
	TOTALS		70%	58%	56%	56%	45%	64%	70%	47%
	******		*****	*****						

Figure 13: Specimen output showing space utilizations by work station type and by block

DETAILS OF OCCUPATION OF ROOMS OF WS 9 IN BLOCK 4

ROOM SIZES AFTER STAGE 1 ARE 25 20 20 10 5

ROOM SIZES AFTER STAGE 2 ARE 25 20 20 10 5
* ROOM SIZES AFTER STAGE 2 ARE 25 20 20 10 10
* ROOM SIZES AFTER STAGE 2 ARE 25 20 20 10 10 2

FINAL ROOM SIZES AND ALLOCATIONS ARE GIVEN BELOW

SIZES	25	20	20	10	10	2
PERIOD						
1	15	31	31	31	31	0
2	15	31	31	31	31	0
3	31	37	31	31	31	0
4	31	37	31	31	31	0
5	22	38	22	22	22	0
6	22	38	22	22	22	0
7	22	22	22	39	22	0
8	22	22	22	39	22	0
9	29	36	36	36	36	0
10	29	36	36	36	36	0
11	29	36	36	36	36	0
12	36	36	36	36	42	0
13	18	23	23	23	34	0
14	18	23	23	23	34	0
15	19	23	23	23	34	0
16	19	23	23	23	34	0
17	25	24	24	24	43	32
18	25	24	24	24	43	32
19	27	24	24	0	24	32
20	27	24	24	0	24	32
21	26	16	16	16	42	0
22	26	16	16	16	42	0
23	28	16	16	16	42	0
24	28	16	16	16	42	0
25	13	17	17	0	17	35
26	13	17	17	0	17	35
27	14	17	17	0	17	41
28	14	17	17	0	17	41
29	21	30	40	21	30	0
30	21	30	21	30	34	0
31	21	30	21	30	34	0
32	21	30	21	30	34	0
33	20	0	33	0	42	0
34	20	0	33	0	42	0
35	20	0	40	0	0	0
NUMBER OF PERIODS EMPTY	0	3	0	9	1	27
OVERALL UTILISATION	90%	81%	78%	68%	93%	23%

Figure 14: Specimen details of room usage

5. MAKING USE OF THE OUTPUT

In any project, the first run of the system will usually generate a set of spaces that would add up to an area that would be impracticable to build. Although the programs will have achieved as much compatibility as is possible between the requirements for the different subjects and pupil groups, there will remain a proportion of requirements which do not 'fit together' well and which thus give rise to poor usage of space. This effect is to be expected since the data will have been provided by a number of different people, each of whom will have been asked to think initially only of his own requirements.

The summary outputs will highlight the particular work station types and blocks that are operating least well, and this will focus attention on those parts of the curriculum organization that might beneficially be modified. More specific guidance as to the most productive changes is contained in the detailed output. Figure 15 gives examples of ways in which changes might be made. The changes would be selective, affecting only these parts of the results that were felt to be least satisfactory.

TYPE OF CHANGE	EXAMPLE
CHANGE ORGANIZATIONAL ARRANGEMENTS	Years 1–3 to share specialist facilities rather than providing separate facilities for each year group.
CHANGE SUBGROUP SIZES OR TIMETABLING ARRANGEMENTS	English and mathematics to be cross-blocked rather than being separately block time-tabled.
REDUCE VARIABILITY OF SUBGROUP SIZES	Consider only sizes that are multiples of 5.
SUBSTITUTE ONE WS TYPE FOR ANOTHER	Allow ordinary desk/chair type activities to take place in light practical areas if space is available.
PLAN FOR A HIGHER PROPORTION OF TEACHING TO TAKE PLACE IN OPEN AREAS	Change the proportions of year 3 social studies from 70% closed: 30% open to 50% closed: 50% open

Figure 15: Example of changes that could be made to improve space utilization

The modified information is coded and re-entered to SANSTEST, (see Figure 1). Because of the way the system has been designed, modifications to the input information do not require a complete recoding of the data but are achieved by changing a small number of computer cards. Therefore the scope for punching and coding errors in these subsequent runs is very small. Moreover, few if any of the changes will have materially affected the staffing ratios or overall specifications, so the entire SANSTEST stage of the system can be completed very quickly on all these subsequent runs.

The programs can be re-run as many times as is necessary to produce a result that is architecturally and financially feasible. The initial modifications will be relatively trivial and will not require deep consideration, but as the distillation procedure continues, the decisions will become progressively more fundamental. Should some part of the desired blocking arrangements be sacrificed? Or should it be accepted that the accommodation will

have to be rather more generalized than had been hoped? Or must it be recognized that the range of teaching group sizes envisaged was too ambitious and that rather more uniformity is inevitable? The educationist could use the SANS system to examine the accommodation consequences of each of these possibilities, and the results will help him to make the trade-offs necessary to arrive at an acceptable solution.

There is one final stage to the SANS system before the results are passed on to the architect (see Figure 1). Once a solution has been achieved that is, in outline, viable, the educationist can systematically check through the detailed output to assure himself that there are no unacceptable timetabling implications. He may, for example, wish to avoid situations where first year and fifth year children share the same open plan multi-purpose area at the same time, and the output will show whether this situation would occur, and the number of additional places that would be required to prevent it. On the other hand, in the case of traditional rooms, he will wish to have some confidence that there is sufficient flexibility in the design to take account of all the local problems that make practical timetabling such a difficult task. Again, the output will allow him to recognize this. When he is completely satisfied with the set of spaces and accommodation types that have been generated, the results are ready to be passed over to the architects for more detailed design work.

To conclude briefly, we believe that the system we have described in this report can provide a valuable aid in the design process of a new school and, more generally, in the examination of novel educational concepts. We have been anxious to ensure that the educationist is able to see the implications of his choices rather than have the consequences shielded from him behind an over-simplified result. Although the system requires the educationist to present his ideas unambiguously, it does not compel him to use a level of detail that he feels to be unjustified. However, in those areas where he does have a clear view of the particular arrangements he would like to see implemented, the SANS system does provide him with the means to evaluate them.